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Environmental effects on the Coma cluster luminosity function ⋆

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Abstract. Using our catalogue of $V_{26.5}$ isophotal magnitudes for 6756 galaxies in a region covering $60 \times 25\,\mathrm{arcmin}^2$ in the center of the Coma cluster, plus 267 galaxies in a region of $9.7 \times 9.4\,\mathrm{arcmin}^2$ around NGC 4839, we derive the luminosity function in the magnitude range $13.5 \leq V_{26.5} < 21.0$ (corresponding to the absolute magnitude range $-22.24 < M_{V26.5} \leq -14.74$). The luminosity function for this region is well fitted by the combination of a gaussian in its bright part and of a steep Schechter function (of index $\alpha = -1.8$) in its faint part. Luminosity functions derived for individual regions surrounding the brightest galaxies show less steep slopes, strongly suggesting the existence of environmental effects. The implications of such effects and galaxy formation scenarios are discussed.

Key words: Galaxies: clusters: individual: Coma; galaxies: clusters of; galaxies: luminosity function

1. Introduction

The shape of the luminosity function (LF) of galaxies gives strong constraints on cosmological parameters and formation scenarios since it is closely related to the galaxy mass function (MF) and therefore to the spectrum of initial perturbations (see Binggeli et al. 1988 for a review). For instance, the hierarchical model predicts a MF characterized by an exponential cut-off above a given mass (M^*) and a power law (with index α) at low masses, where the index α is related to the slope n of the power spectrum as $\alpha = (9-n)/6$ with $-3 < n < 0$ (Schechter 1976). Such a typical behaviour has been found in the studies of the LF both for field or group and cluster galaxies, and has been popularized as the "Universal Schechter function".

However this natural link between LF and MF is probably somewhat simplistic since environmental effects expected to be present at least in high density regions like clusters of galaxies have been neglected and could probably play an important role in modifying morphologies, luminosities, etc ...

In the field, recent spectroscopic surveys (Zucca et al. 1995, Ellis et al. 1996) lead to a rather shallow slope ($\alpha \simeq -1$) for the faint luminosity part. For clusters of galaxies, the situation is more intricate. There seems to be nevertheless a consensus that in such systems the slope of the LF is steeper than in the field. Recent works by Bernstein et al. (1995, hereafter BNTUW) and De Propris et al. (1995) give values ranging from $\alpha = -1.4$ to the extreme value of -2.2.

Such large values seem to indicate that a numerous population of faint galaxies is present in clusters and not in the field. Such a segregation could be related either to the formation conditions ("nature" effects, where denser initial density peaks leading to clusters fragment into smaller subunits than in the field) or to environmental effects ("nurture" effects, where e.g. the intra-cluster gas would be able to confine small cluster galaxies, which would not be the case in the field).

Comprehensive comparative determinations of LFs in the field and in clusters as well as in various environments

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⋆ Based on observations collected at the Canada-France-Hawaii telescope, operated by the National Research Council of Canada, the Centre National de la Recherche Scientifique of France, and the University of Hawaii

inside clusters will clearly give valuable clues on the above topics.

Such studies are generally restricted by insufficient observational material. Either the field areas studied are small in order to sample enough objects below M^* (the faint end of the LF), or, on the contrary, the magnitude range obtained is limited when observations are made on large fields in order to increase the number statistics.

Last but not least, background subtraction plays an important role and can in general be treated only statistically since redshifts are not available for the faintest objects.

In this paper, we present a survey of the Coma cluster performed at CFHT covering a region of 60 x 25 arcmin^2, plus a second region of 9.7 × 9.4 arcmin^2 around NGC 4839, in which $V_{26.5}$ magnitudes have been obtained for 6756 and 267 galaxies respectively, down to $V_{26.5}$=22.5, and address these questions.

In section 2 we briefly describe the data thus obtained and discuss the question of background subtraction. In section 3 we present the results for the LF in various regions of the cluster. Finally, in section 4 we discuss these results, in particular the steep slope at the faint end and the consequences of the dynamical history of the cluster on the LF.

2. The data

2.1. Galaxy magnitudes

The results presented below are based on a CCD photometric catalogue of 6756 galaxies, obtained with a mosaic of images covering a region of 60 × 25 arcmin^2, equivalent to 2.4 × 1 h_{50}^{-2} Mpc^2, centered on the two brightest central galaxies of Coma (NGC 4874 and NGC 4889), plus one field of 9.7 × 9.4 arcmin^2 around NGC 4839 (the group south-west of Coma) with 267 galaxies. The latter region was treated separately and was not included in the overall luminosity function derived in section 3.1. All the details concerning the observations and data reduction are given in a paper by Lobo et al. (1996). In the present study, the quantitites of interest taken from this catalogue are the coordinates and $V_{26.5}$ isophotal magnitudes for each galaxy.

We have checked that magnitudes computed inside the isophote 26.5 are optimal for our observational conditions and closely approximate total magnitudes. $V_{26.5}$ magnitudes will simply be noted as V hereafter.

Absolute magnitudes were computed with a distance modulus of 35.74 adopting a flat cosmology ($q_0 = 1/2$, $\Lambda = 0$, and Hubble's constant $H_0 = 50$ km s^{-1}Mpc^{-1}) and taking into account a K-correction of 0.03 magnitudes to all galaxies. The turnover of the counts is observed at V $\sim$ 22.5, but there is most probably also a loss of completeness for galaxies brighter than 22.5, as discussed e.g. by BNTUW. Note that our central surface brightness limiting detection value of $\mu_0 = 24$ mag/arcsec^2 might have missed some very faint surface brightness objects (this value was simply determined *a posteriori* by the standard analysis of the V vs μ_0 plot and a closer look at the objects with fainter μ_0.)

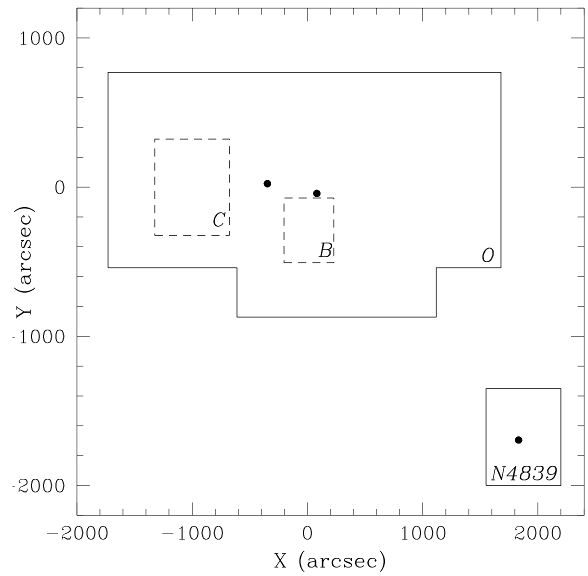

Fig. 1. Map of some of the regions where we computed the luminosity function. Main regions are labeled, and the dots indicate the positions of the big galaxies NGC 4874 and NGC 4889 in the centre, and NGC 4839 in the south-west frame. Coordinates are given relatively to the GMP centre located at $\alpha = 12^h\ 57.3^m$, $\delta = 28^\circ$ 14.4' (1950.0). North is up, east is to the left.

2.2. Subsamples

In our search for possible environmental effects, we also derived luminosity functions for different smaller spatial zones: one square region of 52.2 arcmin^2 coinciding exactly with that analyzed by BNTUW in their analysis of the deep luminosity function in the R-band, two square regions covering approximately the same area but this time centered on the bright galaxies NGC 4874 and NGC 4889, which have recently been shown to be the centers of groups (see Biviano et al. 1996), a third square region covering the same area, containing no bright galaxy and offset from the cluster center to the south-east by $(-1000, 0)$ arcsec, and the region of 9.7 × 9.4 arcmin^2 around NGC 4839 defined above. These five regions will be labeled *B*, *N4874*, *N4889*, *C* and *N4839* respectively while the Overall region will be labeled *O* (see Fig. 1).

2.3. Background subtraction

Field subtraction is never straightforward and the fact that we only possess observations in the cluster region (no additional frames of regions devoid of groups or clusters were obtained during the run) and one filter only, complicates even further this task. We therefore decided to divide the sample into two subsamples according to brightness.

For bright galaxies (V< 18.5), we first identified cluster members in our V catalogue by matching positions (to better than 5 arcsec) with the Godwin et al. (1983, hereafter GMP) catalogue. Then we identified the galaxies as cluster members, either by redshift or by location in the colour-magnitude band defined by Mazure et al. (1988). A more detailed description of this procedure can be found in Biviano et al. (1995). Apparent magnitudes were converted to absolute ones by subtracting the distance modulus for Coma. Since the colour-magnitude band criterion is reliable at least up to b = 19.0 (as tested by redshift information, see Biviano et al. 1995), we decided to consider this subsample to be fairly correct up to this value, which typically corresponds to V $\sim$ 18. At this stage we have 309 cluster members; field galaxies in this magnitude range constitute $\sim$ 25% of the V catalogue in the region of observations.

For intermediate to faint galaxies (V $>$ 18), redshift determinations are rare and extrapolation of the colour-magnitude band is highly speculative. We used the imaging catalogue of field galaxies from the ESO-Sculptor Faint Galaxy Redshift Survey (Bellanger *et al.* 1995, Arnouts et al. 1996, hereafter also noted as Sculptor data) to estimate the number of fore + background objects per magnitude bin. In this survey, observations were made for more than 40 fields covering a total area of 1440 arcmin^2 with seeing conditions similar to those of our run. Total V magnitudes were obtained for a complete sample of objects ranging from V = 18.0 to V = 23.5. We built a mean field with these counts and scaled it to the area covered by our observations, obtaining a sample of 3782 field galaxies in the range $18.0 < V \leq 22.5$. Symmetrical error bars for each magnitude bin take into account fluctuations among the different frames. We then subtracted these field counts to the corresponding magnitude range of our V catalogue. This approach is valid since the Coma cluster is essentially free of internal extinction (Ferguson 1993), and the galactic reddening is negligible in the direction of Coma (Burstein & Heiles, 1982). The subtraction of the field counts was made directly bin per bin, after binning the Sculptor and the Coma V catalogues in exactly the same way with 0.5 mag/bin. We then converted apparent magnitudes to absolute ones. Cluster member galaxies add up to 884 for $18.0 < V \leq 21.0$ ($-17.74 < \mathrm{M}_V \leq -14.74$), and field galaxies represent 47.3% of the observed initial sample.

For the faintest magnitudes (V> 21.0), it can be seen from Fig. 2 that problems do exist for field estimation, as

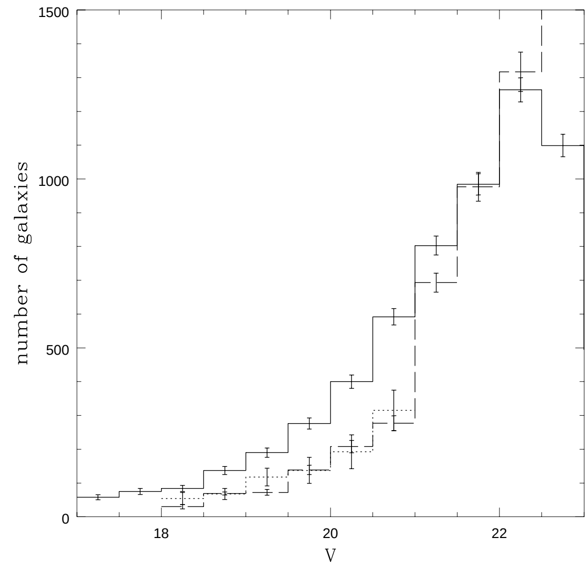

Fig. 2. Raw counts derived from the observations (continuous line), background ESO-Sculptor counts (long-dashed line) and luminosity function for Coma after field subtraction (dotted line) in the Overall region O for V$\leq$ 21.0 (see text).

the field counts exceed those in the region of observations. This causes a decrease towards negative values of the luminosity function (after field subtraction). This phenomenon is most probably due to the fact that the Coma sample is incomplete at these magnitudes, therefore making the background subtraction hazardous. We will therefore limit our analyses to V$\leq$ 21.0. The resulting error bars for Coma data after field subtraction were computed in each magnitude bin using the classical formula: $\sigma_C^2 = \sigma_{all}^2 + \sigma_f^2$, where subscript C stands for Coma data after field subtraction, *all* for the observed field plus Coma galaxy number distribution, and f for field galaxies. σ_{all} is assumed to be poissonian, so we take it to be equal to $\sqrt{N_{all}}$; σ_f is the error bar for each magnitude bin as computed by Arnouts *et al* (1996). The result obtained by direct bin subtraction is questionable due to binning effects. However, we have tested and confirmed its reliability by fitting the field counts with mathematical functions and then subtracting this fit to our observations in order to discard any possible irregularities particular to the background fields in question. The result was the same, within error bars, as that obtained after direct subtraction. To strengthen our confidence in these results we also performed the same general process of field subtraction using the field counts derived from the Canada-France Redshift Survey (CFRS, Lilly *et al.* 1995a) in a field of 400 arcmin^2, which have the advantage of having been made with the same instrument as ours and under similar conditions. We indirectly obtained isophotal V magnitudes, $\mathrm{V}_{iso} \geq 17.5$, by means of their observed I_{iso} (*iso* being a sufficiently low isophote

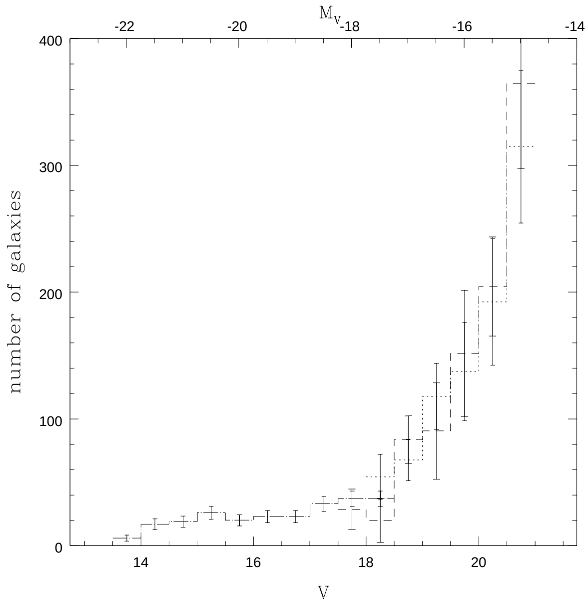

Fig. 3. Luminosity functions derived for Coma in the Overall region: the bright part (dot-dashed line) is superposed to the fainter ones: respectively, that obtained after subtraction of the CFRS field counts (dashed line) and that derived with the background provided by the ESO-Sculptor survey (dotted line).

to be sure that isophotal magnitudes thus derived are very close to total magnitudes and to our own 26.5 isophote), and of 3" aperture V and I magnitudes. The luminosity function we obtained for Coma after scaled subtraction of the CFRS counts was consistent with that computed with Sculptor (see Fig. 3). However, as the error bars we computed - following the same recipe as above - for the V_{iso} magnitude bins from the CFRS are larger than the Sculptor ones (because the CFRS surveyed area is smaller) we prefered to continue our analyses with the luminosity function obtained by subtracting the Sculptor counts. For the whole magnitude range ($13.5 \leq V \leq 21.0$), when we compare the number of galaxies in the brighter range to that in the faint range, we find compatible values in the overlap zone (i.e. the bins centered on V = 17.75 and 18.25), within error bars. This "junction condition" will play an important role in the discussion of the quality or the robustness of the results presented in section 3.3. We therefore chose to adopt for the luminosity function the values determined from the colour-magnitude band criterion up to V = 18.5 (included), as this method is less sensitive to number count fluctuations in the extreme bins.

Note that statistical handling of contamination by foreground and background objects, as we have done it, is allowed due to the high density of the cluster core. However, the procedures described for eliminating fainter "intruders" are tricky and errors are expected from background fluctuations, specially at the faint end (where we seem to have somewhat overestimated the field number counts), as discussed by Colless (1989). Apart from several possible problems of background estimation, we nevertheless confide in the robustness of our result: the simple fact that we obtain the same luminosity distribution when using two different field galaxy surveys seems to indicate that our background subtraction is correct.

We therefore obtain a continuous magnitude distribution of 1074 objects in the range V$\leq$ 21.0, corresponding to the absolute magnitude range $M_V \leq -14.74$, which we shall now use to draw and characterize the luminosity function.

3. The luminosity functions

3.1. The overall luminosity function

The luminosity function in the b-band was recently studied in detail by Biviano et al. (1995), who fit their data with the following functions and/or their combinations: 1) a Schechter function (S), 2) a Gauss function (G), and 3) a Gamma distribution (also called Erlang function). In this paper we will fit our V data by a Maximum-Likelihood technique (following the method described in Bevington & Robinson 1992) with the following functions:

$$S(M_V) = K_S\, 10^{0.4(\alpha+1)(M_V^*-M_V)} \exp[-10^{0.4(M_V^*-M_V)}] \quad (1)$$

$$G(M_V) = K_G\, \exp[-(M_V-\mu)^2/(2\sigma^2)] \quad (2)$$

and by their combination.

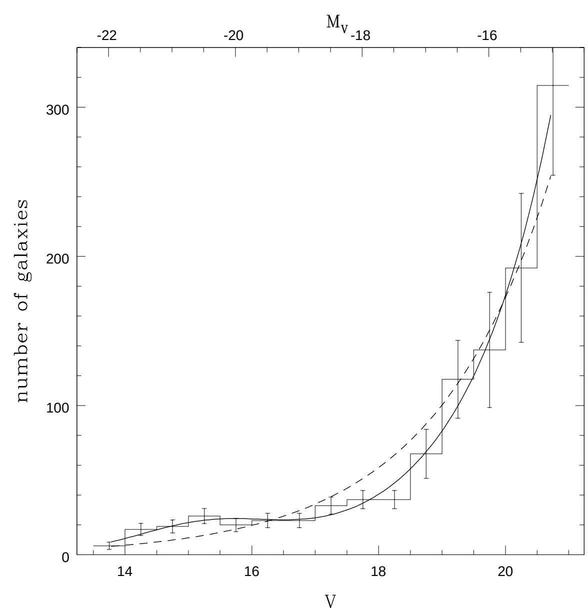

Fig. 4. Schechter (dashed-line) and Schechter + Gauss (continuous line) fits to all the Coma data in the Overall region.

We give in Table 1 the best fit results obtained after excluding the three brightest cluster members. The reason

Table 1. Different fits to the whole luminosity function.

Function	Mag range for the fit	M_V^*	α	μ	σ	χ^2_R
S	$-22.24 < M_V \leq -14.74$	-29.0 ± 2.0	-1.59 ± 0.02			3.1
S + G	$-22.24 < M_V \leq -14.74$	-22.7 ± 0.4	-1.80 ± 0.05	-20.4 ± 0.2	1.1 ± 0.3	0.6

G=Gauss, S=Schechter

for this has been discussed by Biviano et al. (1995), and is essentially due to the influence of these three galaxies on the shape of the gaussian. This condition limits the data to the range $-22.24 < \mathrm{M}_V \leq -14.74$. The columns of Table 1 are the following: (1) function used to fit the luminosity function, (2) magnitude range for the fit, (3) to (6) values of the best fit parameters, (7) reduced chi-square.

It can be seen from this Table and Fig. 4 that a single Schechter function does not fit the data. On the other hand, the combination of a Schechter and a Gaussian fits the data quite well.

We have also tried to fit the luminosity function with the combination of a Schechter and an Erlang function (see Biviano et al. 1995). The Maximum-Likelihood-Ratio test (see e.g. Meyer 1975) shows that both G and E functions fit the data equivalently, so we will therefore limit our discussion to the G function. We can note that the value of M_V^* is well constrained and the slope of the Schechter function is quite steep: $\alpha = -1.8$. The characteristics of the Gaussian are quite similar to those found in the b-band by Biviano et al. (1995), assuming a color index $(b-V)$=0.9. This will be discussed in section 4.2.

3.2. Luminosity function in several subsamples

BNTUW recently addressed the same question in a much smaller region of Coma, but using deeper photometry taken with a different filter (R). In particular, they fitted the luminosity function over the range 15.5<R<23.5 (approximately equivalent to 16.5<V<24.5 if we take a typical value $(V-R)$=1.0 for cluster galaxies). Parametrizing it as a power law $\mathrm{dN/dL} \propto \mathrm{L}^\alpha$, they derive $\alpha = -1.42 \pm 0.05$ ($\chi^2_R = 0.8$), and their 95% confidence interval is $-1.57 < \alpha < -1.25$. The fact that we found a spectral index for the Coma luminosity function notably steeper than that estimated by BNTUW worried us at first, because we expected to observe the same stellar populations in V and R.

This led us to estimate the luminosity function for region *B*, and also for a few sub-regions (defined in section 2.2) characterized by obvious peculiar features, in exactly the same manner as BNTUW. All these luminosity functions were fitted in the interval 16.5<V≤21.0 by the same power law as used by BNTUW. Results are given in Table 2.

Table 2. Power law fits to the data in the magnitude interval $16.5 < V \leq 21.0$ ($-19.24 < M_V \leq -14.74$) for different regions.

Region	Power law slope α $\pm1\sigma$ error	N_{gal}	surface area $arcmin^2$
O	-1.81 ± 0.03	1025	1422
B	-1.71 ± 0.11	60	52
N4874	-1.58 ± 0.10	57	51
N4889	-1.51 ± 0.13	32	51
N4839	-1.74 ± 0.11	54	117
N4839	-1.79 ± 0.13	38	51
C	-1.88 ± 0.10	77	116

Table 3. Probabilities for the α indices obtained in various subsamples to be the same as the α index of the parent sample *O*.

C	*N4874*	*N4889*	*B*	*N4839*
0.38	0.04	0.04	0.38	0.95

If we take the magnitude distribution of the *O* sample as the parent distribution for all subsamples, we can test the null hypothesis that the magnitude distributions of these subsamples are drawn from this parent distribution. We parametrize the magnitude distributions by their α indices; assuming that the errors on these indices are normally distributed around the observed values, we give in Table 3 the probabilities that the α's are the same as that derived for the reference sample *O*.

The results in Tables 1-3 lead to the following comments:

- The α index of the power law in the overall cluster (-1.81) is consistent with the index of the Schechter function derived previously (see Table 1).
- The index found in region *B* is much steeper than that of BNTUW (see discussion below).
- The power law index found for regions *N4874* and *N4889* is significantly flatter, while for region *N4839* it is identical to that computed for *O*.

These results could be due to the environmental properties of regions *N4874* and *N4889*, and could also be linked to other properties described in a previous paper (Biviano et al. 1996). However, the flatness of α is probably not simply due to the existence of groups around these two galaxies, since such a flat index is not observed

in the *N4839* region. As a comparison, we have also derived α in a region without peculiar features (region C) but with a similar number of galaxies, and we find a value that does not differ very much from the overall index. We will discuss the hypothesis of environmental effects and its implications in section 4.3.

3.3. Quality of our results

First of all, we emphasize the fact that we have done our analyses and fits using a large number of galaxies both in the central part of Coma and in the two background samples. We give below several arguments justifying the robustness of our results.

The fact that subtracting the background contribution estimated from two different samples (Sculptor and CFRS) leads to similar results strongly suggests that our background subtraction is correct. However, various kinds of effects could affect this background subtraction. First, we could have made some mistakes when comparing our V magnitudes to those derived by the Sculptor survey team. We can test the effect of such errors by subtracting the background after shifting it by $V = \pm 0.5$, and performing again our Schechter plus Gauss fit. The α indices resulting from such fits on the O sample turn out to be -1.79 ± 0.03 and -1.48 ± 0.05, as compared to -1.80 ± 0.05 (Table 1). However, in both cases, the "junction condition" (defined in section 2.3) is badly fulfilled; moreover, M^* is out of the magnitude range used in the fitting procedure. $\alpha = -1.48$ is a limiting value allowed by our data; however, it still represents a steeper slope than that observed for field galaxies. In addition, we checked that our magnitudes do not differ significantly from V_{Kron} (the Sculptor data actually consists of Kron magnitudes).

Second, it could also be possible that the actual background of Coma differs from what we consider as a universal one, but unless we obtain redshifts for all the galaxies in the Coma area, this cannot be checked. We will try to approximate such a local variation in two ways:

1. There can be effects due to the total number of galaxies subtracted, the slope of the background remaining constant. Again, the "junction condition" suggests that this first effect is certainly weak.
2. There could be a variation of the background slope, with the "junction condition" still being fullfilled. Notice that BNTUW have discussed and simulated the variation of data completeness from bin to bin. If the effective background slope derived from the Sculptor data has been overestimated, the final α index will be flatter than the real one, and this effect will be superimposed to that due to the incompleteness of the sample. In this case, the value of $\alpha = -1.8$ is an upper limit (algebraically). On the other hand, if the background slope has been underestimated, both effects will be antagonistic, and no definite conclusion can be drawn.

With the likely hypothesis that our background subtraction is correct, we now turn to the comparison between our results for region B and those of BNTUW. They have estimated $\alpha = -1.42 \pm 0.05$ while we have found: $\alpha = -1.71 \pm 0.11$ (see Table 2). However, the range of magnitudes of their analysis ($15.5 < R < 23.5$) is much larger than ours ($16.5 < V \leq 21$, assuming $V - R \sim 1$).

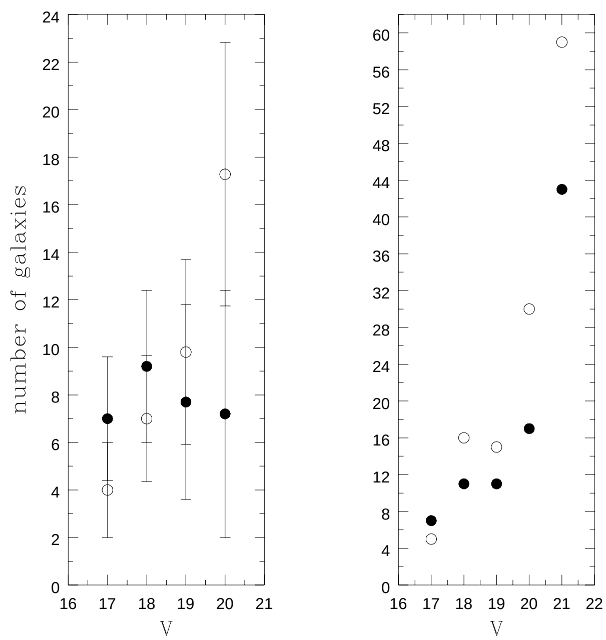

Fig. 5. Comparison between Bernstein et al. (1995) data (filled circles) and our own (open circles) in the B region. Left panel: luminosity functions. Right panel: raw counts

We display BNTUW's data (their Table 2) and ours on the left panel of Fig. 5, as well as the raw counts on the right panel of the same figure. There is clearly a large discrepancy in the two samples, even in the bright bins where the same galaxies should be observed in V and R. Notice that for the range $18 < V < 20$, the data indicated by BNTUW show a very irregular behaviour and would lead to a flat slope; it is only the data for larger values of V which allow them to find $\alpha = -1.42$.

One cannot tell if the discrepancy between our slope in the B region and that found by BNTUW is due to the $(V - R)$ transformation. However, we have confidence in our result, since the α index that we obtain differs by less than one σ from that derived for the O region. B is a fair sub-sample, representative of the parent sample, even if the number of galaxies belonging to it is small.

All the reasons presented in this section show the reliability of the *Overall* result, thus reinforcing our confidence in the result obtained for the B sub-sample.

4. Discussion and Conclusion

4.1. Steep spectral index

The steep Schechter index derived above for the intermediate to faint galaxies ($\alpha = -1.8$) suggests the existence of an excess dwarf population compared to the field, where the slope is rather $-1.3 < \alpha < -1.1$ (see e.g. Zucca et al. 1995, Ellis et al. 1996, and references therein). Recently, deeper counts from HST data have been performed by Driver et al. (1995); but these authors have shown that models using a Schechter function with $\alpha = -1.8$ cannot really account for the observations.

This steep index is in clear contradiction with previously derived values for both groups and clusters (e.g. Ferguson & Sandage 1991), and for Coma in particular (Thompson & Gregory 1993), which were all much flatter. However, several other observations of galaxy clusters show an abrupt rise in the faint end of the luminosity function, thus revealing the presence of a large number of faint galaxies. A value of $\alpha = -1.8$ was determined by Driver et al. (1994) for a z=0.2 cluster ($-24 < M_R < -16.5$). De Propris et al. (1995) derive $\alpha = -2.2$ for the cores of four rich nearby clusters (A2052, A2107, A2199 and A2666) in the approximate magnitude ranges $-15 < M_B < -11$ and $-16 < M_I < -13$. These authors also present a complete discussion and revision of the values of the Schechter index obtained for other clusters and for the field.

In fact, the value of the Schechter index clearly depends on the part of the luminosity function which is being studied: the faint part of a cluster luminosity function is steeper than the bright part. BNTUW also found a dramatic upturn at $M_R = -11.9$ (R=23), where the steep (dwarf) component takes over. This change of slope is in contradiction with what has been found up to now for field photometric surveys (Lilly et al. 1995b, Ellis et al. 1996).

The over-abundance of dwarf galaxies in clusters is an observational result that one has to take into account in the general theory of segregation according to galaxy density, such as the well known segregation by type, etc... Babul & Rees (1992) suggest that dwarf galaxies "will be strongly influenced by the local intergalactic medium; those in high-pressure environments [the intracluster medium] will be preserved while those in low-pressure ones [the field] will fade away", their gas being easily ejected by supernova driven winds. This is an idea very close to the concept that the bias parameter depends on the local density (Gnedin 1996). Explaining why there is an over-abundance of dwarf galaxies is however beyond the scope of this paper.

4.2. Double distribution of luminous galaxies

If we consider the luminous galaxies (up to V$\sim$17), part of them follow a Gauss distribution while the others are distributed according to the Schechter function previously determined. One can therefore say that, at least as far as their luminosity properties are concerned, there are two different populations of luminous galaxies.

We have compared the results described above to those obtained for the b magnitudes of the same objects by Biviano et al. (1995), using a typical colour index ($b - V \sim 0.9$).

Before making any other comment, one must first notice that the depth of these two analyses is different: b$<$ 20.0 versus V$\leq$ 21.0, which roughly corresponds to b$\leq$ 22. However, we also stress that for the two analyses we have found that galaxies are distributed in a composite manner, following a gaussian plus a Schechter distribution. When comparing the V and b luminosity functions, one should expect the fainter part to be better constrained in the V-band, where photometry goes deeper, and this is the case. Furthermore, we confirm the excess of bright galaxies (well fit by a gaussian in this work) followed by a flattening already apparent in the works of Rood (1969), Godwin & Peach (1977), Lugger (1986), Thompson & Gregory (1993), Kashikawa et al. (1995), and well defined in Biviano et al. (1995).

However, the characteristics of the two fits are not identical: it has not been possible to find the same gaussian fit in V and in b (that is, same central magnitude and dispersion) simultaneously with identical values for the Schechter distribution parameters, even in equivalent magnitude ranges (b$<$ 20.0 and V$<$ 19.0). However, the mean value μ of the Gauss distribution is (within error bars) generally the same. These results are in agreement with the eye impression: the dip in b appears far more obvious than in V, where the bump is apparently more "diluted"; notice that there is a slight indication that the σ value given in Table 1 for the S + G fit is larger than the σ given in Table 2 of Biviano *et al* (1995). However, correlation tests clearly show that the b and V distributions are highly correlated in the bright range ($M_V \leq -17.24$): both parameters τ of Kendall and ρ of Spearman (see e.g. Kendall & Stuart 1977) are close to 1.0 (0.866 and 0.971, respectively).

This difference between the b and V data would suggest the existence of blue galaxies (highly populated with young stars) outstanding in the b filter observations but being missed in V. To test this hypothesis it would be useful to have infra-red photometry or, alternatively, ultraviolet data. Quite recently, Donas et al. (1995) presented UV photometry for the Coma cluster and proposed the idea that a starburst event has taken place less than 1 Gyr ago. By the galaxy colour indices ($m_{UV} - b$) they infer that residual star formation is still present in some of them; these galaxies also show peculiar spectra with emission lines indicative of enhanced star formation in the past or still in course (Caldwell et al. 1993); these lines are surprisingly strong for their morphological classification (early-type E-S0). Bluer passbands are the most sensitive

to star formation signatures, so this kind of burst would be sufficient to shift some of the galaxies in Coma towards brighter magnitudes in b, affecting V magnitudes only slightly and thus causing the different behaviours of the luminosity functions in b and V. For the moment, this scenario is only speculative and we intend to investigate further this subject in future works.

4.3. Environmental effects

Table 2 shows that the α indices are steep in the overall cluster and region *C*, while flatter for the two groups *N4874* and *N4889*, contrary to *N4839*. We have already shown that the regions surrounding NGC 4874 and NGC 4889 do have particular properties, in particular a kernel map has revealed that they were both surrounded by an excess of bright galaxies (Biviano et al. 1996); since the α index we compute is that characterizing the intermediate and faint galaxy populations, this implies a lack of faint dwarf galaxies in these two regions. This result suggests an environmental effect in the cluster core correlated to the presence of these two substructures.

The mere presence of these two giant galaxies obviously implies that the luminosity functions in the regions surrounding these two galaxies differ from that in any other zone of the cluster, at least in the bright part. Since the power-law fit is made in a magnitude interval located far from the magnitudes of these two galaxies, the slopes we have found in regions *N4874* and *N4889* do indicate that the luminosity functions in these regions really show a different behaviour.

Although the number of faint galaxies in these two regions is very high, the corresponding luminosity is very small: 76% of the number of galaxies in the *N4874* area represent only 5.5 % of the total luminosity, while the four most luminous ones account for more than 50%. It is also interesting to notice that if we compare the light distribution in regions *N4874* and *N4889* to that in the *O* region, we find that there is more light (i.e. larger galaxies) in the luminous part, followed by less light (i.e. small galaxies) in the faint range, just as if a balancing process was in progress.

The relative lack of faint galaxies in regions *N4874* and *N4889* might be linked to the recent history of these two subclusters. It is generally believed (see e.g. Merritt 1985) that the cD (or D) galaxies result from a cannibalism process occuring in a group; the subsequent infall of the group into a cluster gives it the appearance of a sub-cluster. The gravitational field of these bright galaxies in the group is locally so important that a large number of very small or dwarf galaxies must be satellites of the brightest ones, i.e. must be more strongly linked to the bright galaxies than to the group as a whole. We can speculate that when the group falls into the central region of a large cluster, the clouds of satellites are strongly affected in their trajectories by the tidal field and this could cause a rapid shower of dwarf galaxies towards the largest galaxies.

¿From this point of view, we can understand the different index values of the *N4874* and *N4889* groups compared to that infered for the *N4839* group as due to a difference in their history. If the *N4839* group has not yet crossed the cluster, then the satellite shower has not yet happened. The history of this sub-cluster has been the target of controversial discussions between authors defending different scenarios (cf. Burns et al. 1994, Colless & Dunn 1996). However, observational evidence seems to indicate that this group has actually crossed the main cluster (e.g. Caldwell et al. 1993) though not through the very central regions, as simulations show that tidal disruption would then have occured (González-Casado et al. 1994; see also Biviano et al. 1996 for further details). This scenario supports our interpretation of the cause for the different luminosity function slopes in the various groups.

4.4. Summary of our results

We have firmly established (with good statistics) that the luminosity function in the central part of the Coma cluster shows the following characteristics:

– The slope of the luminosity function is very steep, $\alpha = -1.8$, suggesting the presence of a huge number of faint and dwarf galaxies in the Coma cluster compared to the field.
– Although both b and V luminous galaxies are well described by a composite distribution (a gaussian plus a Schechter function), their distributions are not identical. We therefore conclude that from the luminosity point of view, there are two kinds of galaxies.
– Luminosity functions derived for the two central subclusters present a relatively faint slope of $\alpha = -1.5$, suggesting that there are fewer faint and dwarf galaxies in these regions than in the cluster as a whole. We have suggested a dynamical explanation for this observation, and because the luminosity function of the group around NGC 4839 is the same as for Coma, it is also suggested that the history of this group is different from that of the two other sub-clusters.

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